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Introduction to artificial intelligence application in industry 5.0 revolution

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ABSTRACT:

In today's time, with the digital revolution and the advent of technologies both customers and organizations are getting exposed to a larger amount of information than ever before, making organizational decision making challenging. Industrial Revolution 4.0 led to the emergence of smart factories with the development of technologies such as Internet of Things (IoT), Sensors, Industrial Internet of Things (IIoT), Cyber-Physical Systems, Cloud Computing, Big Data, and Artificial Intelligence (AI). Their prime focus was to increase productivity and mass production through automation and somewhere superseded humans over technology-enabled machines. With the uprising of Industry 5.0, the vision for this industrial revolution is perceived as supporting not superseding humans. Humans and AI may have multiple roles to play in an organization, but organizations in which both humans and AI act as decision agents need to emphasize managing the impact of technological involvement on human performance and vice-versa, to work in collaboration. This study aims to understand the role of human and AI-enabled machines in organizational decision-making. Different strategies related to human-machine collaboration existing in research are also discussed to enable the organizations, as well as the researchers, to identify the most suitable strategy for organizational decision making in industry 5.0, where human-machine collaboration is the primary goal. The first three industrial revolutions were driven respectively by mechanization, electrification, and automation which had gradually transformed the agrarian economy into a manufacturing-based economy. While we are currently living to see the fourth industrial revolution (also known as Industry 4.0) unfolding around us, the world is poised for the next big leap, the fifth industrial revolution or Industry 5.0. Industry 5.0 has been defined on the basis of principles of Human Centrality, Sustainability, and Resiliency by considering that the fourth industrial revolution does not pursue these goals.

KEYWORDS: IIOT, Industry 5.0, Artificial Intellegence.

1. INTRODUCTION

Since the earliest industrial revolution, humans understood advancement can be achieved through the use of technology. There have been many developments in the last few centuries, such as steam plants, assembly lines, and computers, developed in command to upsurge productivity and proficiency as well as speed up growth. The industrial revolution brought changes to the economy and society. Industry 5.0 transforms this paradigm and creates change by reducing technological stress and assuming that the true power of reducing technological stress and assuming that the true power of progress lies in the interaction amongst guy and apparatus.

Vehicles, clothing, houses and weapons have been designed and manufactured by humans and/or with the help of animals in the past centuries. With the emergence of Industry 1.0 in 1974, industrial production began to change significantly. Fig. 1 shows an overview of the evolution of Industrial x.0 [1]. The development time for the first three revolutions was around 100 years, and it took only 40 years to reach the fourth from the third. In 1800s, Industry 1.0 evolved through the development of mechanical production infrastructures for water and steam-powered machines. There is a massive gain in the economy as production capacity has increased. Industry 2.0 evolved in the year of 1870 with the concept of electric power and assembly line production. Industry 2.0 focused primarily on mass production and distribution of workloads, which increased the productivity of manufacturing companies. Industry 3.0 evolved in 1969 with the concept of electronics, partial automation and information technologies. Industry 4.0 evolved in 2011 with the concept of smart manufacturing for the future. The main objective is to maximize productivity and achieve mass production using emerging technologies [2], [3]. Industry 5.0 is a future evolution designed to use the creativity of human experts working together with efficient, intelligent and accurate machines [4].

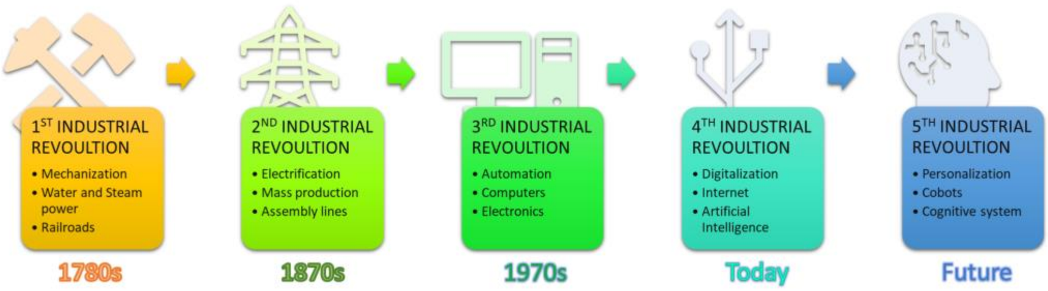

Figure 1. Industry Revolution

Industry 1.0 – It was the chief industrial revolution, initiating the transition to new manufacturing's systems using water and steam. There was a great gain in terms of having more variety of goods and building a better quality of life for others. . The period for this revolution began in the 1790s and was mostly confined to Britain. Industry 1.0 can also be considered as the commencement of the industry values which riveted equally on eminence, proficiency and scale.

Industry 2.0 – After the 1840s, it was the time when the second revolution took place. It instigated in the 19th era with the unearthing of voltage and assemblage streak creation. Introduction of electricity was authorized in factories to develop modern production lines.

Industry 3.0 – It was the third revolution, introduced in the 1970s, in which the use of information technology and electronics was implemented.

Industry 4.0 – It is the fourth industrial revolution or we can say the time of the smart machines, robots, artificial intelligence, or many other technologies. The Fourth Industrial Revolution, 4IR, or Industrial 4.0 consider rapid changes in technologies, industries, and social patterns and progressions in the 21st century as a result of increased communication and smart automation in new era

Industry 5.0 – It's a Fifth Revolution of this era that can be started from upcoming 2023. There will be every industrial production, manufacturing with the help of Robotics and advanced smart technologies. The new beginning of Industry 5.0 takes our era towards new society i.e., Society 5.0, which is also known as the super-smart society, which may be the final bridge between machine and man and personalization for humans. The introduction of Industry 5.0 in conjunction with society 5.0 may lead to robots and drones delivering medicalsupplies, meals, and medicinesto patients infected with disease. Medical, rapid diagnostics,reconnaissance and observing, development of personal protective equipment novel novels, and vaccine development are all advancing thanks to nanotechnology, the surreptitious to the fifth industrialized rebellion and the forthcoming. There will be innovative.

2. Application of industry 5.0

1.Close interaction between humans and machines.
2.The advent of 5G will allow manufacturers to become more aware of mobile operators.
3.Emphasize more in object building and culture - mass production.
4.Additional use of cloud robots and easy-to-use remote robots APIs.

Sr. No.	Industry	Revolution Duration	Area	Benefits	Limitation
1	1.0	1780-1868	Steam and Water Based Power Machines.	Revolution in transportation and traveling using mechanization.	Limited Features, Expensive Machinery, High Maintenance, Air Pollution
2	2.0	1870-1914	Electrical Energy, Assembly lines, and Mass production.	Electric Engines, Electric Boilers.	Expensive Electricity Charges, High Energy Consumption
3	3.0	1969-2010	Electronics Machines, Computer System, Automation	Accurate Machinery, Less Power Consuming, and Reduced Manpower	Consuming more space, requires fast internet, limited speed processing
4	4.0	2011 – till now	Robotics, Cyber System, Network, AI,IoT	High Accurate Working, Cost–Efficient, Smart Working	Cyber-attacks, ethical issues,
5	5.0	Approx. in 2025	Self-optimization, AI management, Io E, Blockchain	Fully Automation Controlled System, Fast and Reliable Working, High Security	---------

Table 1. Industry 5.0 Application

3. Problems and limitations in Industry 5.0

Industry 5.0 resolves most of the manufacturing issues associated with removing human workers from different procedures. However, it must incorporate additional forward-thinking skills since humans may add innovative manufacturing skills in the coming days. There are numerous skills in the developing stage, some of them pointed in this section.

1. Before incorporating advanced skills into industrial management, there is a need for how an autonomous system can incorporate ethical principles.

2. There is a need for proper verification and validation of ethical behaviour inside the autonomous system model.

3. Implementation operation transparencies , fast and competent manufacturing might have significance in an overproduction phenomenon.

4. The outcome results must be understandable ethical behaviour solutions in an autonomous scheme. In particular, industrial experts are facing adapting and implementation issues.

5. Tuning and validation will avert somewhat serious problems among technology, experts, stockholders, society, and businesses.

4. Prospective technologies of industry 5.0

From the previous sections, it can be implied that Industry 4.0 has solely focused on improving profits by concentrating only on product quality and process efficiency using different digital technologies. However, it has widely ignored the need for human intelligence and failed to acknowledge the impact of digital technologies on the environment and society. Hence Industry 5.0 is predicted to include the two key missing elements, the inclusion of humans and sustainable development. In addition, it is also expected to provide flexibility and agility that industries require to quickly respond to the changing market conditions and customer preferences. However, although most industrial leaders and many scholars have predicted leveraging human creativity as the key difference of Industry 5.0, few other scholars argue that Industry 5.0 would just be an evolution or an incremental advancement of Industry 4.0 technologies and practices .

The key differentiating factors between the industrial revolutions are shown in Figure 2.

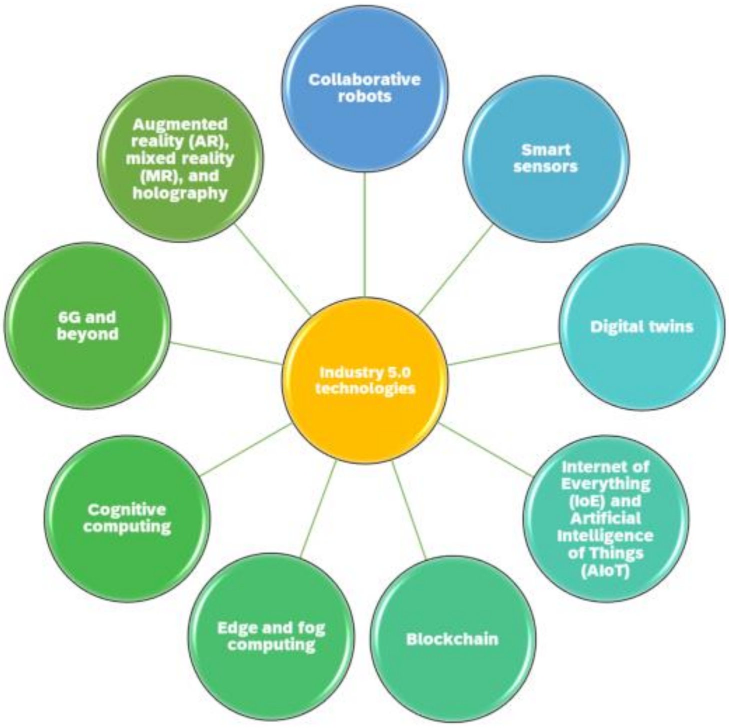

Figure 2. Diagrammatic representation of prospective Industry 5.0 technologies

4.1 Collaborative robots (cobots)

Although robots are used in industries for many decades the highly connected fourth industrial revolution robots are designed to work autonomously without human supervision, and they already play an active role in many factories currently. However, instead of working independently, the fifth industrial generation robots are expected to collaborate with humans and work under his guidance. Thanks to the advancement in digital technologies such as artificial intelligence, machine learning, and conventional robotics that gave rise to the next-gen collaborative robots or “cobots.

KUKA, a leading manufacturer of industrial robots and automation systems has already introduced their first-generation lightweight collaborative robot named “LBR iiwa” which is currently being used in assembly and production lines of Ford, Daimler, BMW, Skoda, and many other automotive companies. As the cobots are small and mobile, they are capable of working in almost all the areas of an industrial setup such as laboratories, handling of raw material, production and assembly lines, material handling, transportation, packaging, quality control, and shipping of finished products to the customers. As the cobots are highly affordable, versatile, and easy to deploy, it gives the advantage of a level playing field for the small-scale industries to compete with large conglomerates and multinational corporations.

For instance, a cobot installed in Craft and Technik Industries in India which is an automotive part manufacturing company has shown a 20% improvement in the product quality by handling the monotonous job of loading and unloading components from a CNC machine while simultaneously performing inspection . Stela Laxhuber, a mid-sized German manufacturer of drying machinery products has reported a tremendous improvement in its productivity and quality of parts after employing a cobot in their welding cell. The welding operation which typically takes a day was completed by a 6-axis KUKA KR Cybertech cobot with the required precision and top-notch craftmanship in a mere 50 min .

4.2 Smart sensors

A sensor is an electronic device that can sense any changes in physical properties and convey them through an appropriate change in electrical output. For instance, a thermocouple sensor responds to the change in temperature by producing a suitable output voltage. While a conventional sensor has only the base sensing elements, a smart sensor system can independently perform data collection, data conversion, data processing, and establish communication to an external system such as a cloud server which are some of the critical requirements of future smart factories. Such extended capabilities are achieved through a suitable base sensing element, microprocessor, communication, and memory modules all embedded in one system. Basically, smart sensors and actuators are an integral element of IoT, CPS, automation, robotics, and all intelligent systems which are the driving force behind Industry 4.0 and Industry 5.0 technologies.

4.3 Digital twins

The accurate digital replication of a physical system that acts as its virtual counterpart is the digital twins. In general, using the data gathered from the original model and mirroring it on its replicate model to simulate and understand the real-time behavior is the core concept of twinning [2]. The concept of using "twins" was believed to be in practice since the late 1960s when NASA was working on the Apollo space mission. NASA scientists have made two identical spaceships to allow precise mirroring of the conditions that the spaceship in orbit experiences with its twin on the earth . However, with the advancements in digital technologies, currently, it is possible to mirror the condition on a digital model rather than on a physical model and hence derived its name, "digital twins". Even the term "digital twins" was first coined by NASA in its 2010 report to denote its Simulation- Based Systems Engineering [4].

4.4 Internet of everything (IoE) and artificial intelligence of things (AIoT)

The term "Internet of Everything" was coined by Cisco to describe the all-around connectivity between, people, things, data, and processes. The hybrid connection enables to gain of more valuable information which can be converted into new capabilities, rich experiences, and exceptional opportunities. If IoT refers to the connection of physical objects with the internet which is a single technology transition, IoE contains many technology transitions in which IoT is one of the parts. The philosophy of IoE revolves around connecting the billions of devices, objects, and common things around the world with sensors that give them wide networking capability and make them smarter.

4.5 Blockchain

Blockchain is a digitally managed, distributed, and decentralized ledger used to store both tangible and intangible assets in a business network in the form of transactions in an immutable format. The characteristics of the technology in providing trust, transparency, and traceability make it attractive for applications where transactions are involved [5]. Each block is a file where the transactions are permanently recorded and when a new transaction is performed it gets added to the block similar to adding a new page to a ledger. In simple terms, the technology can be defined as a chain that contains data blocks in the chronological sequence that are permanently stored in encrypted form as a distributed ledger that is tamper-proof or fake proof. As all businesses rely on data and information flow across various stakeholders it is critical to ensure that the flow is accurate and faster, and Blockchain is the ideal technology that can deliver information from a permanent ledger only to the approved members. Originally created as a hack-proof system for banking and financial institutions, the Blockchain technology with its decentralized, distributed, and immutable features is proclaimed to be a game-changer for all the sectors that require secure data sharing within and outside their organizations [5].

4.6 Edge and fog computing

The current efficiency of cloud-computing technology is insufficient in analyzing a large volume of data generated in a shorter time which affects the service quality and the overall performance of the network and the IoT system. Hence, the disadvantages of cloud computing technology can be overcome by using edge computing. Edge computing is a distributed computing and storage framework deployed near the source where the data is created which keeps data on the local parts of the network or the edge devices, instead of using a centralized data server. It allows data from IoT devices to be processed at the edge (in the local system itself) before sending it to the cloud which improves the response time and saves network bandwidth.

Edge computing and Fog computing are essentially the same in terms of leveraging the computing capabilities that are available within a local network. The key difference between cloud, edge, and fog computing lies in the place at which data processing is done. The difference between edge, fog, and cloud computing is shown in Figure 3.

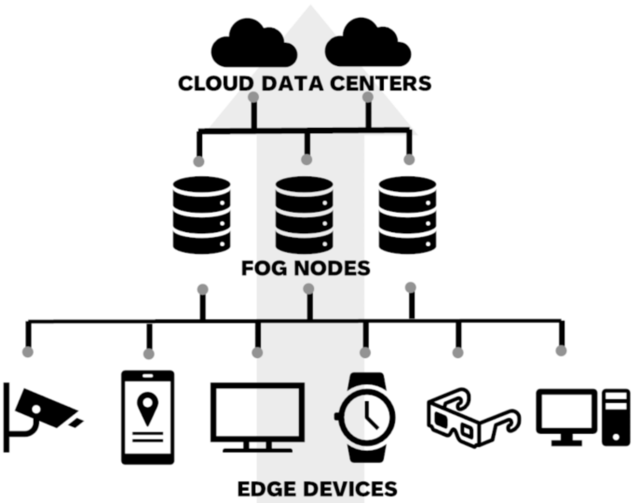

Figure 3. Difference between edge, fog, and cloud computing

4.7 Cognitive computing

Cognitive computing refers to the set of technology platforms that uses computerized models to mimic human thought processes to solve complex problem. Although some scholars classify cognitive computing as a subset of artificial intelligence, basically they are two entirely different disciplines but with overlapping methodologies. While the focus of artificial intelligence is to reflect reality and produce accurate results based on a set of theories and algorithms, cognitive computing is built on participation from two distinct interdisciplinary fields such as computing (artificial intelligence, machine learning, pattern recognition, data mining) and cognitive science (visual recognition, language processing, psychological, philosophy, and anthropology) to augment human thinking and reasoning abilities similar to the human brain

5. Sustainability dimension of industry 5.0

From the various sections of this article, it can be inferred that the entire concept of Industry 4.0 and Industry 5.0 technologies revolves around collecting, processing, monitoring, storing, and analyzing data from numerous connected sources to improve the process efficiency, make decisions, and learn on the go. The computing, information, and digital technologies come together to achieve this common goal. Apart from manufacturing industries, these technologies are used independently or along with other supporting technologies in banking, financial, biomedical, health care, social media, automotive, aerospace, autonomous vehicles, and numerous other sectors.

The industrial revolutions are all about making products in a better way to meet consumer demand. However, some scholars have combined all the latest advancements in other fields such as bionics, synthetic biotechnology, genetic engineering, quantum computing, nanotechnology, smart self-healing materials, and Brain-computer interfaces as a few technology enablers of industry 5.0

6. Industry 5.0 components

Industry 5.0 represents a paradigm shift involving the digital transformation of value-creating and delivery processes at the micro and macroscopic analysis levels [11]. Therefore, adaptive factories, logistics, suppliers, products, customers, and stakeholders are the major smart components that collectively constitute the hyper-connected socio-ecological value-creating ecosystem under Industry 5.0 .

6.1 Adaptive Smart Factory **(ASF)** concept refers to transitioning from a more traditional semi-automatic and rigid production system to a highly automated, flexible, digitalized, and resilient production system . This concept centers around data-driven manufacturing, which entails system-wide and real-time data collection, integration, and analysis across all production and business functions . The ASF is characterized by agile production processes, product customization capability, energy awareness, productivity, higher product and process innovation capacity, and production reliability . Compared to Industry 4.0, the smart factory under Industry 5.0 is associated with more disruptive technological innovations such as C-CPS, IIoT, IEMS, and CAI. The SAF of Industry 5.0 takes a more human-centric approach to manufacturing and leverages technology to adapt the production processes to the benefit of the human workforce. More importantly, the smart factory of Industry 5.0 is adaptive because it can adjust its elements (e.g. production systems or production scheduling) to meet structural shifts in consumer behavior or market dynamics .

6.2 Smart Products can communicate, store, and self-process data and have the necessary integrability to interact with and within the industrial ecosystem. Besides communicating their operational status in real-time, smart products can describe their entire usage and lifecycle history . Under Industry 5.0, smart products are characterized by a wide range of technological properties, from being sensor-equipped and AI-driven to being built from smart or engineered living materials that offer significant self-regulation and environmental responsiveness functions . By communicating the processing and assembly information at the production stage, usage behavior at the consumption stage, and end-of-life recovery information, smart products offer immense productivity, sustainable product innovation, and business model innovation opportunities under the Industry 5.0 agenda.

6.3 Smart Customers are at the heart of Industry 5.0, allowing businesses to offer data-driven services [12]. Although smart products can communicate valuable lifecycle data to the manufacturer, their implications for customer engagement and lifecycle management are somewhat limited. Smart customers increasingly integrate with IoP and personal digital devices to interactively communicate with their digital selves and create a collective intelligence network at a global scale. Smart customers can digitally integrate and interact with other smart components of Industry 5.0, communicate their current and future preferences to the product and service provider, and contribute to realizing customer-driven and circular manufacturing under Industry 5.0

6.4 Smart Supply Chain transforms traditional, rigid, and linear supply chains into agile, modular, scalable, and highly interconnected digital supply networks . Smart supply chains use Industry 5.0 technologies such as edge computing, CAI, C-CPS, and IIoT to establish dynamic digital threads between various supply nodes involving equipment, processes, delivery channels, planning platforms, and even customers. It acts on real-time data collection from sensors, connected resources, and distributed systems and uses cognitive computing and advanced data analytics to drive actionable insights [14]. Proactive risk mitigation, cost-effectiveness, asset efficiency, flexibility, and resilience to disturbances (e.g. global crises such as the COVID-19 pandemic) are among the advantages of smart supply chains .

6.5 Smart Logistics component 5.0 involves adding the necessary autonomy and intelligence to logistics to meet the agility, interconnectedness, productivity, and efficiency requirements of the data-driven and real-time economy [15]. This process involves digitalizing various traditional components of logistics, including supply chain logistics (e.g. local and global operations structure), inbound logistics, outbound logistics (e.g. order-based delivery management), intralogistics (e.g. manual part feeding to production stations), and logistics routing. The smartification of logistics operations relies on the combination of advanced technologies such as IIoT, blockchain, and edge computing [16]. Predictive delivery management systems, autonomous transportation systems, smart warehousing, intelligent shelves, and smart containers are among the major components of smart logistics under Industry 5.0 [17].

The integrative and disruptive force of Industry 5.0 deeply concerns stakeholders all along the entire lifecycle of products and services [18]. Industry 5.0 and the underlying digital transformation are expected to impact consumer behavior, innovation lifecycle, employment market, distribution of wealth, workers' rights, and degradation of natural resources globally [19]. The smart stakeholder component describes the ability of all Industry 5.0 stakeholders, such as individual manufacturers, suppliers, distributors, technology providers, consultancy firms, universities, and governmental agencies, to interconnect and communicate seamlessly and align with the overall goal of digitalization for sustainable development. Recent technological advancements such as 5 G and upcoming 6 G networks, blockchain, IoE, satellite broadband, and cloud services play an essential role in developing the smart stakeholder component of Industry 5.0 [20].

7. Conclusion

If the industry experts are to be believed the world is already in the midst of the fourth industrial revolution in which a myriad of disruptive digital technologies are married to various industrial machines and processes to collect data and establish a channel of communication between them to deliver products at a lower cost. The integration of the various intelligent machines and processes of an industrial unit with the help of new-age digital and computing technologies creates an eco-system that is connected, smart and agile. Besides, the entire supply chain is controlled, streamlined, and automated to collect, monitor, and optimize real-time data to enable high efficiency right from procuring raw materials till the product is delivered to the customers.

If Industry 3.0 was predominantly driven by computerization, then Industry 4.0 is driven by marrying digital technologies with physical systems that make them smarter and work independently without human intervention. However, from the discussion, it can also be implied that Industry 4.0 has focused on improving profits by concentrating solely on product quality and process efficiency using different digital technologies. But it has widely ignored the need for human intelligence and failed to acknowledge the impact of digital technologies on the environment and society. Like the previous industrial revolutions, the technologies of Industry 4.0 also have the destructive potential to promote automation and alienate humans from the factory shopfloor which could result in job loss and create inequality and imbalance in society. Hence the need to either give the technologies a miss or upgrade them to emphasize the inclusiveness of humans into the system and to focus on eco-friendliness is critical, both of which are expected to be fulfilled by the next industrial revolution.

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